DATA ASSIMILATION AND MODEL SIMULATIONS IN THE CALIFORNIA CURRENT

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LONG-TERM GOALS

The long-term goal of this research is to develop, verify and apply numerical ocean prediction models to eastern boundary coastal regions in order to improve our scientific understanding of the structure and dynamics of such regions.

OBJECTIVES

The broad objective of this research is to aid in the development of a reliable modeling capability for eastern boundary current regions. The specific objective is to carry out and extensively verify several DieCAST model simulations of the annual cycle in the California Current. We also wish to develop and apply digital filter initialization (DFI) as a diagnostic tool in numerical ocean prediction.

APPROACH

The general approach is to carry out increasingly complex numerical simulations of the California Current using the DieCAST regional model, and to verify the simulations against ONR's extensive eastern boundary current (EBC) data sets. An iterative version of digital filter initialization (DFI) will be verified as a diagnostic tool in several idealized test cases, and then it will be applied to quasi-synoptic hydrographic data from the California Current and the Alboran Sea. Diagnostic results from the Alboran Sea application will be verified using direct measurements of the vertical velocity made by quasi-isobaric RAFOS floats.

WORK COMPLETED

The DieCAST A-grid, low-dispersion (nearly 4th order) regional model (Dietrich 1997) was adapted to the California coastal domain with lateral boundary conditions prescribed using data from both an observed monthly climatology and a global numerical model. Two six-year long numerical simulations were completed. One of the simulations uses a climatological annual cycle of wind stress forcing, while the other simulation includes an

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additional wind stress enhancement near each coastal headland that is representative of that observed (eg. Enriquez and Friehe 1995). Preliminary results (below) are very interesting and encouraging.

An iterative form of DFI was applied to the idealized test cases and an optimal version of the method was obtained. It is now being applied to data sets from the California Current (ONR's CTZ and EBC programs) and the Alboran Sea (EC's OMEGA project).

A study of the Atlantic Jet in the Alboran Sea and a numerical simulation of dense water overflow of topography were completed.

RESULTS

Using climatological forcing, the DieCAST model reproduces many of the main features of the observed annual cycle of the California Current including the separation of the coastal jet from the coast in late summer and its offshore migration in autumn and winter. Coastal eddies in the simulation form primarily off the major headlands, especially Cape Mendocino and Point Arena. The surface eddy kinetic energy is in the range of that observed and it undergoes a seasonal cycle with a phase that varies with distance from shore similar to that observed. The additional forcing by the headland wind jets is found to produce both local and remote changes to the simulated annual cycle.

In a separate study, the DieCAST model was shown to simulate dense water overflow of topogrophy better than standard ocean models because of its higher order accuracy and its low numerical dispersion.

The optimal form of DFI is able to diagnose the vertical velocity in an idealized growing baroclinic frontal wave with a relative accuracy of 10%. Using DFI, a closed cyclonic eddy observed off Point Arena California was diagnosed to have negligible vertical velocity on the scale of the eddy itself, but to have very significant vertical velocities (w~30m/d at 100m) associated with sub-eddy scale meanders in the otherwise circular flow around the eddy. Lagrangian vertical excursions of water parcels was estimated to be over 100m due to the downstream (azimuthal) propagation of the meanders around the eddy. A role for these sub-eddy scale features in the vertical transport of water properties is hypothesized.

Using currents diagnosed by DFI from hydrographic data, the vorticity of the Atlantic Jet in the Alboran Sea was shown to be positive along its entire path, including the part of its path that has anticyclonic (negative) curvature.

IMPACT/APPLICATIONS

Our California Current annual cycle simulations are among the most advanced ones to date. Because of the excellent data sets being used, the model verifications will represent the standards against which other models will be evaluated in the future. Our results concerning the existence of strong sub-eddy scale vertical velocities off Point Arena are new and, if substantiated by the present OSU research with the EBC data, they suggest a possible role for such features in the vertical eddy transport of water properties.

TRANSITIONS

This research on data assimilation and simulations in the California Current is in broad support of the efforts at FNMOC (M. Clancy) and NRL-Stennis (J. Kindle) to develop a real-time analysis and forecasting capability, including biology, for this region. This support manifests itself in close coordination and timely information exchange on such topics as model properties, experimental set-up, regional modeling difficulties, comparison and exchange of results, methods of model verification, and so forth.

The DFI methodology has been accepted as the major diagnostic tool for estimating the ageostrophic circulation and vertical motion in the EC-sponsored OMEGA project. This multinational European project completed six quasi-synoptic cruises in the western and central Mediterranean last year. DFI will also be utilized by J. Barth (OSU) to study the dynamics of coastal eddies using data from the EBC synoptic surveys.

RELATED PROJECTS

I am collaborating with J. Barth (OSU) in his application of the DFI diagnostic method to the EBC synoptic survey data.

I am collaborating with D. Dietrich (MSU-CAST) in a study of the dense water overflow of topography.

I am collaborating with A. Viudez and J. Tintore (UIB, Spain) in their diagnostic studies of mesoscale variability in the Alboran Sea.

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